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### Visual attention and active vision

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## Bibliography

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- Alata, O., & Quintard, L. (2009). Is there a best color space for color image characterization or representation based on multivariate gaussian mixture model? *Computer Vision and Image Understanding*, 113(8), 867–877.
- Attneave, F. (1954). Some informational aspects of visual perception. *Psychological Review*, 61, 183–193.
- Attneave, F. (1955). Symmetry, information, and memory for patterns. *The American Journal of Psychology*, 68(2), 209–222.
- Backer, G., Mertsching, B., & Bollmann, M. (2001). Data- and model-driven gaze control for an active-vision system. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 23(12), 1415–1429.
- Bahnsen, P. (1928). Eine untersuchung uber symmetrie und asymmetrie bei visuellen wahrnehmungen. *Zeitschrift für Psychologie*, 108, 129–154.
- Bailey, T., & Durrant-Whyte, H. (2006). Simultaneous localization and mapping (SLAM): Part ii. *IEEE Robotics & Automation Magazine*, 13(3), 108–117.
- Ballard, D. H. (1991). Animate vision. *Artificial Intelligence*, 48, 57–86.

- Barlow, H. B., & Reeves, B. C. (1979). The versatility and absolute efficiency of detecting mirror symmetry in random dot displays. *Vision Research*, 19, 783–793.
- Bauer, B., Jolicoeur, P., & Cowan, W. B. (1996). Visual search for color targets that are or are not linearly-separable from distractors. *Vision Research*, 36(10), 1439–1465.
- Bay, H., Ess, A., Tuytelaars, T., & Van Gool, L. (2008). Speeded-up robust features (SURF). *Computer Vision and Image Understanding*, 110(3), 346–359.
- Bay, H., Tuytelaars, T., & Van Gool, L. (2006). SURF: Speeded up robust features. In *ninth European Conference on Computer Vision (ECCV)*. Graz, Austria.
- Baylis, G. C., & Driver, J. (1993). Visual attention and objects: evidence for hierarchical coding of location. *Journal of Experimental Psychology: Human Perception and Performance*, 19(3), 451–470.
- Baylis, G. C., & Driver, J. (1994). Parallel computation of symmetry but not repetition within single visual shapes. *Visual Cognition*, 1, 377–400.
- Beck, D. M., Pinsk, M. A., & Kastner, S. (2005). Symmetry perception in humans and macaques. *Trends in Cognitive Sciences*, 9(9), 405–406.
- Beis, J., & Lowe, D. G. (1997). Shape indexing using approximate nearest-neighbour search in high-dimensional spaces. In *Conference on Computer Vision and Pattern Recognition*, (pp. 1000–1006). Puerto Rico.
- Belongie, S., Malik, J., & Puzicha, J. (2002). Shape matching and object recognition using shape contexts. *IEEE Transactions of Pattern Analysis and Machine Intelligence*, 2(4), 509–522.
- Bindemann, M., Scheepers, C., & Burton, A. M. (2009). Viewpoint and center of gravity affect eye movements to human faces. *Journal of Vision*, 9(2), 1–16.
- Bornstein, M. H., & Stiles-Davis, J. (1984). Discrimination and memory for symmetry in young children. *Developmental Psychology*, 20(4), 637–649.
- Borotschnig, H., Paletta, L., Prantl, M., & Pinz, A. (2000). Appearance-based active object recognition. *Image and Vision Computing*, 18, 715–727.

- Borst, A., & Egelhaaf, M. (1993). Detecting visual motion: Theory and models. In F. A. Miles, & J. Wallmann (Eds.) *Visual Motion and its Role in the Stabilization of Gaze.*, (pp. 3–27). Elsevier Science.
- Brooks, R. A. (1999). *Cambrian Intelligence: The Early History of the New AI*. The MIT Press.
- Bruce, H. B., & Tsotsos, J. K. (2009). Saliency, attention, and visual search: An information theoretic approach. *Journal of Vision*, 9(3), 1–24.
- Carmi, R., & Itti, L. (2006a). The role of memory in guiding attention during natural vision. *Journal of Vision*, 6(9), 898–914.
- Carmi, R., & Itti, L. (2006b). Visual causes versus correlates of attentional selection in dynamic scenes. *Vision Research*, 46, 4333–4345.
- Carmody, D. P., Nodine, C. F., & Locher, P. J. (1977). Global detection of symmetry. *Perceptual and Motor Skills*, 45, 1267–1273.
- Chun, M. M., & Jiang, Y. (1998). Contextual cueing: Implicit learning and memory of visual context guides spatial attention. *Cognitive Psychology*, 36, 28–71.
- Civera, J., Davison, A. J., & Montiel, J. M. M. (2008). Inverse depth parametrization for monocular SLAM. *IEEE Transactions on Robotics and Autonomous Systems*, 24(5), 932–945.
- Corballis, M. C., & Roldan, C. E. (1975). Detection of symmetry as a function of angular orientation. *Journal of Experimental Psychology: Human Perception and Performance*, 1(3), 221–230.
- Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, 3, 201–215.
- Csurka, G., Dance, C. R., Fan, L., Willamowski, J., & Bray, C. (2004). Visual categorization with bags of keypoints. In *European Conference on Computer Vision, Workshop on Statistical Learning in Computer Vision*, (pp. 1–22).
- Davison, A. J., & Murray, D. W. (2002). Simultaneous localization and map-building using active vision. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 24(7), 865–880.

- Davison, A. J., Reid, I. D., Molton, N. D., & Stasse, O. (2007). MonoSLAM: Real-time single camera SLAM. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 29(6), 1–16.
- De Graef, P., Christiaens, D., & d'Ydewalle, G. (1990). Perceptual effects of scene context on object identification. *Psychological Research*, 52, 317–329.
- de Jong (2008). *Top-down selective visual attention during SLAM*. Master's thesis, University of Groningen, The Netherlands.
- De Kuijer, J., Deregowski, J. B., & McGeorge, P. (2004). The influence of visual symmetry on the encoding of objects. *Acta Psychologica*, 116(1), 75–91.
- Delius, J. D., & Nowak, B. (1982). Visual symmetry recognition by pigeons. *Psychological Research*, 44, 199–212.
- Deregowski, J. B. (1971). Symmetry, gestalt and information theory. *The Quarterly Journal of Experimental Psychology*, 23(4), 381–385.
- Dick, M., Ullman, S., & Sagi, D. (1987). Parallel and serial processes in motion detection. *Science*, 237, 400–402.
- Dissanayake, G., Newman, P., Durrant-Whyte, H. F., Clark, S., & Csobra, M. (2001). A solution to the simultaneous localisation and mapping (SLAM) problem. *IEEE Transactions on Robotics and Automation*, 17(3), 229–241.
- Driver, J., & Baylis, G. C. (1995). One-sided edge assignment in vision: 2. part decomposition, shape description, and attention to objects. *Current Directions in Psychological Science*, 4(6), 201–206.
- Driver, J., Baylis, G. C., & Rafal, R. D. (1992). Preserved figure-ground segregation and symmetry perception in visual neglect. *Nature*, 360, 73–75.
- Durrant-Whyte, H., & Bailey, T. (2006). Simultaneous localization and mapping: Part i. *IEEE Robotics & Automation Magazine*, 13(2), 99–108.
- D'Zmura (1991). Color in visual search. *Vision Research*, 31(6), 951–966.
- Egeth, H., & Dagenbach, D. (1991). Parallel versus serial processing in visual search: Further evidence from subadditive effects of visual quality. *Journal of Experimental Psychology: Human Perception and Performance*, 17(2), 551–560.

- Einhäuser, W., Rutishauser, U., Frady, E. P., Nadler, S., Köning, P., & Koch, C. (2006). The relation of phase noise and luminance contrast to overt attention in complex visual stimuli. *Journal of Vision*, 6, 1148–1158.
- Einhäuser, W., Rutishauser, U., & Koch, C. (2008). Task-demands can immediately reverse the effects of sensory-driven saliency in complex visual stimuli. *Journal of Vision*, 8(2), 1–19.
- Enns, J. T., & Rensink, R. A. (1993). A model for the rapid interpretation of line drawings in early vision. In D. Brogan, A. Gale, & K. Carr (Eds.) *Visual Search 2*, (pp. 73–90). London: Taylor and Francis.
- Evans, C. S., Wenderoth, P., & Cheng, K. (2000). Detection of bilateral symmetry in complex biological images. *Perception*, 29, 31–42.
- Farmer, E. W., & Taylor, R. M. (1980). Visual search through color displays: Effects of target-background similarity and background uniformity. *Perception and Psychophysics*, 27, 267–272.
- Ferrari, V., Tuytelaars, T., & Van Gool, L. (2006). Simultaneous object recognition and segmentation from single or multiple model views. *International Journal of Computer Vision*, 67(2), 159–188.
- Findlay, J. M. (1982). Global visual processing for saccadic eye-movements. *Vision Research*, 22(8), 1033–1045. Pb047 Times Cited:240 Cited References Count:26.
- Findlay, J. M., & Gilchrist, I. D. (2003). *Active Vision: The Psychology of Looking and Seeing*. Oxford, UK: Oxford University Press.
- Fisher, C. B., Ferdinandsen, K., & Bornstein, M. H. (1981). The role of symmetry in infant form discrimination. *Child Development*, 52(2), 457–462.
- Fitzpatrick, P. (2003). First contact: an active vision approach to segmentation. In *the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. Las Vegas, Nevada.
- Foster, D. H., & Ward, P. A. (1991). Asymmetries in oriented-line detection indicate two orthogonal filters in early vision. *Proceedings of the Royal Society (London B)*, 243, 75–81.

- Foulsham, T., & Underwood, G. (2007). How does the purpose of inspection influence the potency of visual salience in scene perception? *Perception*, 36(8), 1123–1138. 224GH Times Cited:2 Cited References Count:38.
- Fowlkes, C., Martin, D., & Malik, J. (2003). On measuring the ecological validity of local figure - ground cues. In *European Conference on Visual Perception*.
- Friedman, J. H., Bentley, J. L., & Finkel, R. A. (1977). An algorithm for finding best matches in logarithmic expected time. *ACM Transactions on Mathematical Software*, 3(3), 209–226.
- Frintrop, S. (2006). *VOCUS: A Visual Attention System for Object Detection and Goal-directed Search*, vol. 3899/2006 of *Lecture Notes in Artificial Intelligence (LNAI)*. Springer Berlin/Heidelberg.
- Frintrop, S., & Jensfelt, P. (2008). Attentional landmarks and active gaze control for visual SLAM. *IEEE Transactions on Robotics*, 24(5), 1054–1065.
- Fritzke, B. (1995). A growing neural gas network learns topologies. In *Advances in Neural Information Processing Systems (NIPS'94)*, vol. 7. Denver.
- Gao, D., Mahadevan, V., & Vasconcelos, N. (2008). On the plausibility of the discriminant center-surround hypothesis for visual saliency. *Journal of Vision*, 8(7), 1–18.
- Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton-Mifflin.
- Grammer, K., & Thornhill, R. (1994). Human (homo sapience) facial attractiveness and sexual selection: The role of symmetry and averageness. *Journal of Comparative Psychology*, 108(3), 233–242.
- Grill-Spector, K., Kourtzi, Z., & N., K. (2001). The lateral occipital complex and its role in object recognition. *Vision Research*, 41(10-11), 1409–1422.
- Guivant, J. E., & Nebot, E. M. (2001). Optimization of the simultaneous localization and map-building algorithm for real-time implementation. *IEEE Transactions on Robotics and Automation*, 17(3), 242–257.

- Hargittai, M., & Hargittai, I. (2009). *Visual Symmetry*. Singapore: World Scientific Publishing Co.
- Harris, C., & Stephens, M. (1988). A combined corner and edge detector. In *The Fourth Alvey Vision Conference*, (pp. 147–151). Manchester, UK.
- He, P. Y., & Kowler, E. (1989). The role of location probability in the programming of saccades - implications for center-of-gravity tendencies. *Vision Research*, 29(9), 1165–1181. Ap318 Times Cited:71 Cited References Count:29.
- Heidemann, G. (2004). Focus-of-attention from local color symmetries. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 26(7), 817–830.
- Henderson, J. M., Brockmole, J. R., Castelhana, S., Monica, & Mack, M. (2007). Visual saliency does not account for eye movements during visual search in real-world scenes. In R. v. Gompel, M. Fischer, W. Murray, & R. Hill (Eds.) *Eye movements: A window on mind and brain*, (pp. 537–562). Oxford: Elsevier.
- Henderson, J. M., & Castelhana, M. S. (2005). Eye movements and visual memory for scenes. In G. Underwood (Ed.) *Cognitive Processes in Eye Guidance*, (pp. 213–235). Oxford University Press.
- Hochberg, J., & McAlister, E. (1953). A quantitative approach to figural goodness. *Journal of Experimental Psychology*, 46, 361–364.
- Hoffman, D. D., & Singh, M. (1997). Saliency of visual parts. *Cognition*, 63, 29–78.
- Huk, A. C., & Heeger, D. J. (2000). Task-related modulation of visual cortex. *Journal of Neurophysiology*, 83, 3525–3536.
- Itti, L., Dhavale, N., & Pighin, F. (2003). Realistic avatar eye and head animation using a neurobiological model of visual attention. In B. Bosacchi, D. B. Fogel, & J. C. Bezdek (Eds.) *SPIE 48th Annual International Symposium on Optical Science and Technology*, vol. 5200, (pp. 64–78). Bellingham, WA: SPIE Press.
- Itti, L., & Koch, C. (2000). A saliency-based search mechanism for overt and covert shifts of visual attention. *Vision Research*, 40(10-12), 1489–1506.
- Itti, L., & Koch, C. (2001). Computational modelling of visual attention. *Nature Reviews Neuroscience*, 2(3), 194–203.



- Itti, L., Koch, C., & Niebur, E. (1998). A model of saliency-based visual attention for rapid scene analysis. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 20(11), 1254–1259.
- Jacobs, D. (1996). Robust and efficient detection of salient convex groups. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 18(1), 23–37.
- Julesz, B. (1971). *Foundations of Cyclopean Perception*. Chicago: University of Chicago Press.
- Julesz, B. (1981). Figure and ground perception in briefly presented isodipole textures. In M. Kubovy, & J. R. Pomerantz (Eds.) *Perceptual Organization*, (pp. 27–54). Hillsdale, NJ: Erlbaum.
- Julesz, B. (1984). A brief outline of the texton theory of human vision. *Trends in Neuroscience*, 7, 41–45.
- Kanizsa, G., & Gerbino, W. (1976). Convexity and symmetry in figureground organization. In M. Henle (Ed.) *Vision and artifact*, (pp. 25–32). Springer.
- Karn, K. S., & Hayhoe, M. M. (2000). Memory representations guide targeting eye movements in a natural task. *Visual Cognition*, 7(6), 673–703.
- Kaufman, L., & Richards, W. (1969). Spontaneous fixation tendencies for visual forms. *Perception & Psychophysics*, 5(2), 85–88.
- Ke, Y., & Sukthankar (2004). PCA-SIFT: A more distinctive representation for local image descriptors. In *IEEE Conference on Computer Vision and Pattern Recognition*, (pp. 506–513).
- Kienzle, W., Franz, M. O., Schölkopf, B., & Wichmann, F. A. (2009). Center-surround patterns emerge as optimal predictors for human saccade targets. *Journal of Vision*, 9(5), 7:1–15.
- Kikuchi, M., & Fukushima, K. (2003). Assignment of figural side to contours based on symmetry, parallelism, and convexity. In *Lecture Notes in Computer Science*, vol. 2774. Heidelberg: Springer Berlin.
- Kimchi, R., & Peterson, M. A. (2008). Figure-ground segmentation can occur without attention. *Psychological Science*, 19(7), 660–668.

- Kimchi, R., Yeshurun, Y., & Cohen-Savransky, A. (2007). Automatic, stimulus-driven attention capture by objecthood. *Psychonomic Bulletin & Review*, 14(1), 166–172.
- Koch, C., & Ullman, S. (1985). Shifts in selective visual attention: towards the underlying neural circuitry. *Human Neurobiology*, 4, 219–227.
- Koffka, K. (1935). *Principles of Gestalt Psychology*. London: Lund Humphries.
- Köhler, W. (1947). *Gestalt psychology : an introduction to new concepts in modern psychology*. New York: Liveright. Reissued, 1992.
- Kohonen, T. (1990). The self-organizing map. *Proceedings of the IEEE*, 78(9), 1464–1480.
- Kootstra, G. (2002). *Selection of Landmarks for Visual Landmark Navigation on a Mobile Robot*. Master's thesis, University of Groningen, The Netherlands.
- Kootstra, G., & de Boer, B. (2009). Tackling the premature convergence problem in monte-carlo localization. *Robotics and Autonomous Systems*, 57(11), 1107–1118.
- Kootstra, G., de Jong, S., & Schomaker, L. R. B. (2009). Using local symmetry for landmark selection. In M. Fritz, B. Schiele, & J. H. Piater (Eds.) *Computer Vision Systems*, vol. 5815 of *Lecture Notes in Computer Science*, (pp. 94–103). Springer.
- Kootstra, G., Nederveen, A., & de Boer, B. (2008a). Paying attention to symmetry. In M. Everingham, C. Needham, & R. Fraile (Eds.) *British Machine Vision Conference (BMVC2008)*, (pp. 1115–1125). Leeds, UK.
- Kootstra, G., & Schomaker, L. R. B. (2009a). Prediction of human eye fixations using symmetry. In *Cognitive Science Conference (CogSci)*. Amsterdam, The Netherlands.
- Kootstra, G., & Schomaker, L. R. B. (2009b). Using symmetrical regions-of-interest to improve visual SLAM. In *Proceedings of the International Conference on Intelligent Robots and Systems (IROS)*. St. Louis, USA.
- Kootstra, G., & Schomaker, L. R. B. (submitted). Prediction of eye fixations on complex visual stimuli using local symmetry. *Journal of Vision*.
- Kootstra, G., Ypma, J., & de Boer, B. (2007). Exploring objects for recognition in the real world. In *IEEE International Conference on Robotics and Biomimetics (ROBIO '07)*. Sanya, China.

- Kootstra, G., Ypma, J., & de Boer, B. (2008b). Active exploration and keypoint clustering for object recognition. In *International Conference on Robotics and Automation (ICRA)*. Pasadena, CA.
- Kourtzi, Z., & Kanwisher, N. (2001). Representation of perceived object shape by the human lateral occipital complex. *Science*, 293(5534), 1506–1509.
- Lakoff, G., & Johnson, M. (1999). *Philosophy in the Flesh: The embodied mind and its challenge to Western thought*. New York: Basic Books.
- Land, M. F., & Hayhoe, M. M. (2001). In what ways do eye movements contribute to everyday activities? *Vision Research*, 41, 3559–3565.
- Land, M. F., & McLeod, P. (2000). From eye movements to actions: how batsmen hit the ball. *Nature Neuroscience*, 30, 1340–1345.
- Le Meur, O., Le Callet, P., Barba, D., & Thoreau, D. (2006). A coherent computational approach to model bottom-up visual attention. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 28(5), 802–817.
- Le Meur, O., Le Callet, P., Barba, D., Thoreau, D., & Francois, E. (2004). From low-level perception to high-level perception, a coherent approach for visual attention modelling. In B. E. Rogowitz, T. N. Pappas, & T. N. (Eds.) *Human Vision and Electronic Imaging IX*, vol. 5292 of *Proceedings of the SPIE*, (pp. 284–295). San Jose, CA.
- Lehrer, M. (1993). Why do bees turn back and look? *Journal of Comparative Physiology A*, 172, 549–563.
- Lehrer, M., & Bianco, G. (2000). The turn-back-and-look behaviour: bee versus robot. *Biological Cybernetics*, 83(3), 211229.
- Levi, D. M., & Saarinen, J. (2004). Perception of mirror symmetry in amblyopic vision. *Vision Research*, 44, 24752482.
- Lewis, M. A., & Nelson, M. E. (1998). Look before you leap: Peering behavior for depth perception. In *Proceedings of the fifth international conference on simulation of adaptive behavior on From animals to animats 5*, (pp. 98–103). Zurich, Switzerland.

- Lindeberg, T. (1998). Feature detection with automatic scale selection. *International Journal of Computer Vision*, 30(2), 79–116.
- Locher, P. J., & Nodine, C. F. (1987). Symmetry catches the eye. In J. O'Regan, & A. Lévy-Schoen (Eds.) *Eye Movements: From Physiology to Cognition*. North-Holland: Elsevier Science Publishers B.V.
- Locher, P. J., & Nodine, C. F. (1989). The perceptual value of symmetry. *Computers and Mathematics with Applications*, 17(4-6), 475–484.
- Locher, P. J., & Wagemans, J. (1993). The effects of element type and spatial grouping on symmetry detection. *Perception*, 22, 565–587.
- Lowe, D. G. (1999). Object recognition from local scale-invariant features. In *International Conference on Computer Vision*, (pp. 1150–1157). Corfu, Greece.
- Lowe, D. G. (2001). Local feature view clustering for 3d object recognition. In *IEEE Conference on Computer Vision and Pattern Recognition*. Kauai, Hawaii.
- Lowe, D. G. (2004). Distinctive image features from scale-invariant keypoints. *International Journal of Computer Vision*, 60(2), 91–110.
- Loy, G., & Zelinsky, A. (2003). Fast radial symmetry for detecting points of interest. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 25(8), 959–973.
- Machilsen, B., Pauwels, M., & Wagemans, J. (2009). The role of vertical mirror symmetry in visual shape detection. *Journal of Vision*, 9(12), 1–11.
- Mannan, S., Ruddock, K. H., & Wooding, D. S. (1995). Automatic control of saccadic eye movements made in visual inspection of briefly presented 2-d images. *Spatial vision*, 9(3), 363–386.
- Marola, G. (1989). Using symmetry for detecting and locating objects in a picture. *Computer Vision, Graphics, and Image Processing*, 46, 179–195.
- Marsland, S., Shapiro, J., & Nehmzow, U. (2002). A self-organising network that grows when required. *Neural Networks*, 15, 1041–1058.
- Maybeck, P. S. (1979). *Stochastic Models, Estimation and Control*, vol. 1. New York: Academic.

- Metta, G., & Fitzpatrick, P. (2003). Early integration of vision and manipulation. *Adaptive Behavior*, 11(2), 109–128.
- Metzger, F. (1953). *Gesetze des Sehens*. Frankfurt-am-Main: Waldemar Kramer.
- Mikolajczyk, K., & Schmid, C. (2001). Indexing based on scale invariant interest points. In *IEEE Int. Conf. on Computer Vision (ICCV)*. Vancouver, BC.
- Mikolajczyk, K., & Schmid, C. (2002). An affine invariant interest point detector. In *the 7th European Conference on Computer Vision*, vol. 1, (pp. 128–142). Copenhagen, Denmark.
- Mikolajczyk, K., & Schmid, C. (2004). Scale & affine invariant interest point detectors. *International Journal of Computer Vision*, 60(1), 63–86.
- Mikolajczyk, K., & Schmid, C. (2005). A performance evaluation of local descriptors. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 27(10), 1615–1630.
- Mikolajczyk, K., Tuytelaars, T., Schmid, C., Zisserman, A., Matas, J., Schaffalitzky, F., Kadir, T., & Van Gool, L. (2005). A comparison of affine region detectors. *International Journal of Computer Vision*, 65(1/2), 43–72.
- Moller, A. P., & Thornhill, R. (1998). Bilateral symmetry and sexual selection: a meta-analysis. *The American Naturalist*, 151(2), 174–192.
- Montemerlo, M., Thrun, S., Koller, D., & Wegbreit, B. (2002). FastSLAM: A factored solution to the simultaneous localization and mapping problem. In *Proceedings of the AAAI National Conference on Artificial Intelligence*. Edmonton, Canada: AAAI.
- Montemerlo, M., Thrun, S., Koller, D., & Wegbreit, B. (2003). FastSLAM 2.0: An improved particle filtering algorithm for simultaneous localization and mapping that provably converges. In *Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence (IJCAI)*. Acapulco, Mexico.
- Moravec, H. (1988). *Mind Children*. Harvard University Press.
- Moreels, P., & Perona, P. (2007). Evaluation of features detectors and descriptors based on 3D objects. *International Journal of Computer Vision*, 73(3), 263–284.

- Mozos, O. M., Gil, A., Ballesta, M., & Reinoso, O. (2008). Interest point detectors for visual SLAM. In D. Borrajo, L. Castillo, & J. M. Corchado (Eds.) *Lecture Notes in Computer Science*, vol. 4788, (pp. 170–179). Springer-Verlag.
- Murillo, A. C., Guerrero, J. J., & Sagues, C. (2007). SURF features for efficient robot localization with omnidirectional images. In *IEEE International Conference on Robotics and Automation (ICRA)*, (pp. 3901–3907). Rome, Italy.
- Nagy, A. L., & Sanchez, R. R. (1990). Critical color differences determined with a visual search task. *Journal of the Optical Society of America*, 7(7), 1209–1217.
- Navalpakkam, V., & Itti, L. (2005). Modeling the influence of task on attention. *Vision Research*, 45, 205–231.
- Navalpakkam, V., & Itti, L. (2006a). An integrated model of top-down and bottom-up attention for optimal object detection. In *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, (pp. 2049–2056).
- Navalpakkam, V., & Itti, L. (2006b). Top-down attention selection is fine grained. *Journal of Vision*, 6, 1180–1193.
- Neider, M. B., & Zelinsky, G. J. (2006). Scene context guides eye movements during visual search. *Vision Research*, 46, 614621.
- Nolfi, S. (1996). Adaptation as a more powerful tool than decomposition and integration. In *the Workshop on Evolutionary Computing and Machine Learning, 13th International Conference on Machine Learning*. Bari, Italy.
- Nothdurft, H. C. (1991). The role of local contrast in pop-out of orientation, motion, and color. *Investigative Ophthalmology and Visual Science*, 32(4), 714.
- Noton, D., & Stark, L. W. (1971a). Scanpaths in eye movements during pattern perception. *Science*, 171(3968), 308–311.
- Noton, D., & Stark, L. W. (1971b). Scanpaths in saccadic eye movements while viewing and recognizing patterns. *Vision Research*, 11, 929–942.
- Odekar, A., Hallowell, B., Kruse, H., Moates, D., & Lee, C. Y. (2009). Validity of eye movement methods and indices for capturing semantic (associative) priming effects. *Journal of Speech, Language, and Hearing Research*, 52, 31–48.

- Olivers, C. N., & van der Helm, P. A. (1998). Symmetry and selective attention: a dissociation between effortless perception and serial search. *Perceptual & Psychophysics*, 60(7), 1101–1116.
- Olmos, A., & Kingdom, F. A. A. (2004). McGill calibrated colour image database, <http://tabby.vision.mcgill.ca>.
- Ottes, F. P., Van Gisbergen, J. A. M., & Eggermont, J. J. (1984). Metrics of saccade responses to visual double stimuli: Two different modes. *Vision Research*, 24(10), 1169–1179.
- Ouerhani, N., von Wartburg, R., Hügli, H., & Müri, R. (2004). Empirical validation of the saliency-based model of visual attention. *Electronic Letters on Computer Vision and Image Analysis*, 3(1), 13–14.
- Paletta, L., & Pinz, A. (2000). Active object recognition by view integration and reinforcement learning. *Robotics and Autonomous Systems*, 31, 71–86.
- Palmer, S. E. (1991). Goodness, gestalt, groups, and garner: Local symmetry subgroups as a theory of figural goodness. In G. R. Lockhead, & J. R. Pomerantz (Eds.) *The Perception of Structure. Essays in Honor of Wendell R. Garner*, (pp. 23–40). Washington, DC: American Psychological Association.
- Palmer, S. E. (1992). Modern theories of gestalt perception. In G. W. Humphreys (Ed.) *Understanding Vision: An Interdisciplinary Perspective – Readings in Mind and Language*, (pp. 39–70). Oxford, England: Blackwell.
- Palmer, S. E., & Hemenway, K. (1978). Orientation and symmetry: Effects of multiple, rotational, and near symmetries. *Journal of Experimental Psychology: Human Perception and Performance*, 4(4), 691–702.
- Pao, H., Geiger, D., & Rubin, N. (1999). Measuring convexity for figure/ground separation. In *Proceedings of the Seventh International Conference on Computer Vision (ICCV)*, vol. 2.
- Parkhurst, D. J., Law, K., & Niebur, E. (2002). Modeling the role of salience in the allocation of overt visual attention. *Vision Research*, 42, 107–123.
- Parkhurst, D. J., & Niebur, E. (2003). Scene content selected by active vision. *Spatial Vision*, 16(2), 125–154.

- Parkhurst, D. J., & Niebur, E. (2004). Texture contrast attracts overt visual attention in natural scenes. *European Journal of Neuroscience*, 19, 783–789.
- Pfeifer, R., & Scheier, C. (1999). *Understanding Intelligence*. Cambridge, MA: MIT Press.
- Pomerantz, J. R. (2006). Colour as a gestalt: Pop out with basic features and with conjunctions. *Visual Cognition*, 14(4-8), 619–628.
- Pomerantz, J. R., Sager, L. C., & Stoeve, R. J. (1977). Perception of wholes and of their component part: Some configural superiority effects. *Journal of Experimental Psychology: Human Perception and Performance*, 3(3), 422–435.
- Privitera, C. M., & Stark, L. W. (1998). Evaluating image processing algorithms that predict regions of interest. *Pattern Recognition Letters*, 19, 1037–1043.
- Privitera, C. M., & Stark, L. W. (2000). Algorithms for defining visual regions-of-interest: Comparison with eye fixations. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 22(9), 970–982.
- Rao, R. P. N., Zelinsky, G. J., Hayhoe, M. M., & Ballard, D. H. (2002). Eye movements in iconic visual search. *Vision Research*, 42, 1447–1463.
- Raphael, B. (1976). *The Thinking Computer: Mind Inside Matter*. W.H. Freeman & Co Ltd.
- Reisfeld, D., Wolfson, H., & Yeshurun, Y. (1995). Context-free attentional operators: The generalized symmetry transform. *International Journal of Computer Vision*, 14, 119–130.
- Ren, X., Fowlkes, C. C., & Malik, J. (2006). Figure/ground assignment in natural images. In *Proceedings of the European Conference of Computer Vision (ECCV)*.
- Rensink, R. A., & Enns, J. T. (1995). Pre-emption effects in visual search: Evidence for low-level grouping. *Psychological Review*, 102(1), 101–130.
- Rhodes, G., Proffitt, F., Grady, J. M., & Sumich, A. (1998). Facial symmetry and the perception of beauty. *Psychonomic Bulletin & Review*, 5(4), 659–669.



- Rothganger, F., Lazebnik, S., Schmid, C., & Ponce, J. (2006). 3D object modeling and recognition using local affine-invariant image descriptors and multi-view spatial constraints. *International Journal of Computer Vision*, 66(3), 231–259.
- Rothkopf, C. A., Ballard, D. H., & Hayhoe, M. M. (2007). Task and context determine where you look. *Journal of Vision*, 7(14), 1–20.
- Roy, S. D., Chaudhury, S., & Banerjee, S. (2004). Active recognition through next view planning: a survey. *Pattern Recognition*, 37, 429–446.
- Royden, C. S., Wolfe, J. M., Konstantinova, E., & Hildreth, E. C. (1996). Search for a moving object by a moving observer. *Investigative Ophthalmology and Visual Science*, 37.
- Royer, F. L. (1981). Detection of symmetry. *Journal of Experimental Psychology: Human Perception and Performance*, 7(6), 1186–1210.
- Saarienen, J., & Levi, D. M. (2000). Perception of mirror symmetry reveals long-range interactions between orientation-selective cortical filters. *Neuroreport*, 11, 2133–2138.
- Sasaki, Y., Vanduffel, W., Knutsen, T., Tyler, C., & Tootell, R. (2005). Symmetry activates extrastriate visual cortex in human and nonhuman primates. *Proceedings of the National Academy of Sciences of the United States of America*, 102(8), 3159–3163.
- Schill, K., Umkehrer, E., Beinlich, S., Krieger, G., & Zetzsche, C. (2001). Scene analysis with saccadic eye movements: top-down and bottom-up modeling. *Journal of Electronic Imaging*, 10, 152–160.  
URL <http://adsabs.harvard.edu/abs/2001JEI...10..152S>
- Schmid, C., & Mohr, R. (1997). Local greyvalue invariants for image retrieval. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 19(5), 530–535.
- Scholl, B. J. (2001). Objects and attention: the state of the art. *Cognition*, 80(1-2), 1–46. 433NB Times Cited:184 Cited References Count:184.
- Schumann, F., Einhäuser-Treyer, W., Vockeroth, J., Bartl, K., Schneider, E., & König, P. (2008). Salient features in gaze-aligned recordings of human visual input during free exploration of natural environments. *Journal of Vision*, 8(14), 1–17.

- Se, S., Lowe, D. G., & Little, J. (2002). Mobile robot localization and mapping with uncertainty using scale-invariant visual landmarks. *International Journal of Robotics Research*, 21(8), 735–758.
- Sela, G., & Levine, M. D. (1997). Real-time attention for robotic vision. *Real-Time Imaging*, 3, 173–194.
- Shapiro, L. G., & Stockman, G. C. (2003). *computer vision*. Prentice Hall.
- Sim, R., Elinas, P., & Little, J. J. (2007). A study of the rao-blackwellised particle filter for efficient and accurate vision-based SLAM. *International Journal of Computer Vision/International Journal of Robotics Research Special Joint Issue on Vision in Robotics*, 74(3), 303–318.
- Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: sustained inattention blindness for dynamic events. *Perception*, 28, 1059–1074.
- Sobel, E. C. (1990). The locust's use of motion parallax to measure distance. *Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology*, 167(5), 1432–1451.
- Stark, L. W., & Privitera, C. M. (1997). Top-down and bottom-up image processing. *Neural Networks*, 4(9-12), 2294–2299.
- Tatler, B. W. (2007). The central fixation bias in scene viewing: Selecting an optimal viewing position independently of motor biases and image feature distributions. *Journal of Vision*, 7(14), 1–17.
- Theeuwes, J. (1991). Exogenous and endogenous control of attention: The effect of visual onsets and offsets. *Perception & Psychophysics*, 49(1), 83–90.
- Theeuwes, J. (1992). Perceptual selectivity for color and form. *Perception & Psychophysics*, 51(6), 599–606.
- Theeuwes, J. (1994). Stimulus-drive capture and attentional set: Selective search for color and visual abrupt onsets. *Journal of Experimental Psychology: Human Perception and Performance*, 20(4), 799–806.
- Theeuwes, J., & Kooi, J. L. (1994). Parallel search for a conjunction of shape and contrast polarity. *Vision Research*, 34(22), 3013–3016.

- Thornhill, R., & Gangestad, S. W. (1993). Human facial beauty: Averageness, symmetry and parasite resistance. *Human Nature*, 4, 237–269.
- Thrun, S., Burgard, W., & Fox, D. (2005). *Probabilistic Robotics*. Cambridge, Massachusetts: The MIT Press.
- Thrun, S., Liu, Y., Koller, D., Ng, A. Y., Ghahramani, Z., & Durrant-Whyte, H. (2004). Simultaneous localization and mapping with sparse extended information filters. *The International Journal of Robotics Research*, 23(7-8), 693–716.
- Torralba, A., Oliva, A., Castelhano, S., Monica, & Henderson, J. M. (2006). Contextual guidance of eye movements and attention in real-world scenes: The role of global features on object search. *Psychological Review*, 113, 766–786.
- Townsend, J. T. (1990). Serial and parallel processing: Sometimes they look like tweedledum and tweedledee but they can (and should) be distinguished. *Psychological Science*, 1, 46–54.
- Treisman, A. M. (1985). Preattentive processing in vision. *Computer Vision, Graphics, and Image Processing*, 31(2), 156–177.
- Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology*, 12(1), 97–136.
- Treisman, A. M., & Gormican, S. (1988). Feature analysis in early vision: Evidence from search asymmetries. *Psychological Review*, 95, 15–48.
- Treisman, A. M., & Sato, S. (1990). Conjunction search revisited. *Journal of Experimental Psychology: Human Perception and Performance*, 16(3), 459–478.
- Treue, S. (2003). Visual attention: the where, what, how and why of saliency. *Current Opinion in Neurobiology*, 13(428-432), 428–432.
- Tsotsos, J. K. (1990). Analyzing vision at the complexity level. *Behavioral and Brain Sciences*, 13, 423-469.
- Tsotsos, J. K. (1997). Limited capacity of any realizable perceptual system is a sufficient reason for attentive behavior. *Consciousness and Cognition*, 6(2-3), 429–436.
- Turk, M., & Pentland, A. (1991). Eigenfaces for recognition. *Journal of Cognitive Neuroscience*, 3(1), 7186.

- Tuytelaars, T., & Mikolajczyk, K. (2008). Local invariant feature detectors: A survey. *Foundations and Trends in Computer Graphics and Vision*, 3(3), 177–280.
- Tuytelaars, T., & Van Gool, L. (2004). Matching widely separated views based on affine invariant regions. *International Journal of Computer Vision*, 59(1), 61–85.
- Tyler, C. W. (2000). The human expression of symmetry: Art and neuroscience. In A. Bogdan (Ed.) *ICUS Symmetry Symposium*. Seoul.
- Van Hoof, H. (2008). *Using Different Methods to Direct a Robot's Attention*. Master's thesis, University of Groningen.
- Van Maanen, L. (2009). *Context Effects On Memory Retrieval: Theory And Applications*. Ph.D. thesis, University of Groningen.
- Van Zoest, W., & Donk, M. (2004). Bottom-up and top-down control in visual search. *Perception*, 33, 927–937.
- Van Zoest, W., Donk, M., & Theeuwes, J. (2004). The role of stimulus-driven and goal-driven control in saccadic visual selection. *Journal of Experimental Psychology: Human Perception and Performance*, 30(4), 746–759.
- Varela, F., Thompson, E. T., & Rosch, E. (1991). *The Embodied Mind*. The MIT Press.
- Wagemans, J. (1993). Skewed symmetry: a nonaccidental property used to perceive visual forms. *Journal of Experimental Psychology: Human Perception and Performance*, 19(2), 364–380.
- Wagemans, J. (1995). Detection of visual symmetries. *Spatial Vision*, 9(1), 9–32.
- Wagemans, J. (1997). Characteristics and models of human symmetry detection. *Trends in Cognitive Sciences*, 1, 346–352.
- Wagemans, J. (1999). Parallel visual processes in symmetry perception: Normality and pathology. *Documenta Ophthalmologica*, 95, 359–370.
- Wagemans, J., Van Gool, L., & d'Ydewalle, G. (1991). Detection of symmetry in tachistoscopically presented dot patterns: Effects of multiple axes and skewing. *Perception and Psychophysics*, 50(5), 413–427.
- Walter, W. G. (1950). An imitation of life. *Scientific American*, 182(5), 42–45.

- Walter, W. G. (1951). A machine that learns. *Scientific American*, 185(2), 60–63.
- Walther, D., & Koch, C. (2006). Modeling attention to salient proto-objects. *Neural Networks*, 19, 1395–1407.
- Wang, D., Kristjansson, A., & Nakayama, K. (2005). Efficient visual search without top-down or bottom-up guidance. *Perception & Psychophysics*, 67(2), 239–253.
- Wedema, D. (2009). *Comparing the EKF and FastSLAM solutions to the problem of Simultaneous Localization and Mapping*. Master's thesis, University of Groningen.
- Wertheimer (1945). *Productive Thinking*. New York: Harper & Row.
- Wertheimer, M. (1923). Untersuchungen zur lehre von der gestalt ii. *Psychologische Forschung*, 4, 301–350. Translation published in Ellis, W. (1938). A source book of Gestalt psychology (pp. 71–88). London: Routledge & Kegan Paul.
- Winn, J., Criminisi, A., & Minka, T. (2005). Object categorization by learned universal visual dictionary. In *Tenth IEEE International Conference on Computer Vision*, vol. 2, (pp. 1800–1807). Beijing, China.
- Wolfe, J. M. (1992). "effortless" texture segmentation and "parallel" visual search are not the same thing. *Vision Research*, 32, 757–763.
- Wolfe, J. M. (1994). Guided search 2.0: A revised model of visual search. *Psychonomic Bulletin & Review*, 1(2), 202–238.
- Wolfe, J. M. (1996). Extending guided search: Why guided search needs a preattentive "item map". In . G. D. L. A. Kramer, G. H. Cole (Ed.) *Converging operations in the study of visual selective attention*, (pp. 247–270). Washington, DC: American Psychological Association.
- Wolfe, J. M. (1998). Visual search. In H. Pashler (Ed.) *Attention*. University College London Press.
- Wolfe, J. M. (2001). Asymmetries in visual search: an introduction. *Percept Psychophys*, 63(3), 381–389.
- Wolfe, J. M. (2007). Guided search 4.0: Current progress with a model of visual search. In W. Gray (Ed.) *Integrated Models of Cognitive Systems*, (pp. 99–119). New York: Oxford.

- Wolfe, J. M., Butcher, S. J., Lee, C., & Hyle, M. (2003). Changing your mind: On the contributions of top-down and bottom-up guidance in visual search for feature singletons. *Journal of Experimental Psychology: Human Perception and Performance*, 29(2), 483–502.
- Wolfe, J. M., & Friedman-Hill, S. R. (1992). On the role of symmetry in visual search. *Psychological Science*, 3(3), 194–198.
- Wolfe, L., Cave, K. R., & Franzel, S. L. (1989). Guided search: An alternative to the feature integration model for visual search. *Journal of Experimental Psychology: Human Perception and Performance*, 15, 419–433.
- Yarbus, A. (1967). *Eye Movements and Vision*. New York: Plenum Press.
- Yeshurun, Y., Kimchi, R., Sha'shoua, G., & Carmel, T. (2009). Perceptual objects capture attention. *Vision Research*, 49, 1329–1335.
- Zelinsky, G. J., Zhang, W., Yu, B., Chen, X., & Samaras, D. (2006). The role of top-down and bottom-up processes in guiding eye movements during visual search. In Y. Weiss, B. Schlkopf, & J. Platt (Eds.) *Advances in Neural Information Processing Systems (NIPS)*, vol. 18, (pp. 1569–1576). Cambridge, MA: MIT Press.
- Zwinderman, M., Rybski, P. E., & Kootstra, G. (submitted). A human-assisted approach for a mobile robot to learn 3D object models using active vision. In *Proceedings of the IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. Submitted.

